

LIGHT SOURCE AND
IMAGE READING DEVICE USING THE SAME

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

The present invention relates to a light source that emits light whose spectral characteristics are different by switching between an external electrode lighting mode and an internal electrode lighting mode.

10 2. Description of the Related Art

Conventionally, technology has been proposed where invisible information is obtainable as an image signal by printing invisible information on a specific image—e.g., with a material that transmits visible light and
15 absorbs infrared light—and reading, with an image sensor sensitive to infrared light, light reflected when infrared light is irradiated onto the image.

In applying the aforementioned technology to an image reading device, how to add, as a simple
20 configuration, a configuration for invisible information reading to a configuration for ordinary image information reading has become a problem.

Until now, in order to read both visible information and invisible information, reading has been
25 conducted by switching between a visible light reading

mode and an infrared light reading mode by using a halogen lamp as the illumination light source, using the infrared light components that a halogen lamp inherently has and switching optical filters inserted on a midway
5 optical path, as disclosed in JP-A-6-141145.

Incidentally, in recent years, it is becoming more and more common to use a noble gas fluorescent lamp instead of a halogen lamp as the light source for ordinary image information reading, with the purpose of
10 reducing power consumption and improving reliability.

However, because noble gas fluorescent lamps include practically no infrared light in the components of the irradiation light thereof in ordinary lighting conditions, they cannot be used as they are for
15 invisible information reading, it is necessary to add a separate light source such as an infrared LED, and a problem arises in terms of cost and disposed space.

With respect to this problem, the inventors of the present application have proposed intensifying the
20 infrared light component included in spectral characteristics of the illumination light by switching the lighting modes of a noble gas fluorescent lamp, as described in JP-A-2000-174984.

As one example thereof, the inventors have proposed
25 an image reading device that irradiates light onto a

target and reads the light reflected therefrom, the device including: an airtight container having disposed therein phosphor materials that emit light by ultraviolet rays which are radiated due to discharge; a
5 pair of internal electrodes disposed inside the airtight container; and a pair of external electrodes disposed outside the airtight container, wherein the amount of the infrared component is switched by switching between a mode that causes a discharge between the internal
10 electrodes and a mode that causes a discharge between the external electrodes.

In the mode that causes a discharge between the external electrodes, the discharge is not concentrated at a specific place because the discharge path is formed
15 from a dielectric material such as glass. Thus, an impulse discharge of an extremely short amount of time is ubiquitously generated. As a result, ultraviolet light, which has a high energy, becomes the main component of the components of light emitted from xenon
20 atoms of gas, and it becomes easy to excite the phosphors to emit visible components.

With respect thereto, in the mode where a discharge is caused between the internal electrodes, a dielectric material is not intervened on the discharge path, but a
25 positive column is continuously joined between both

electrodes. As a result, among the components of light emitted from the xenon atoms in the gas, the ratio of infrared light, which has a low energy, rises and the infrared component is directly emitted to the outside
5 without exciting the phosphors. The present inventors actually made prototypes of lamps having these two electrodes and confirmed that the emitted light components are switched.

However, in the mode where the lamp is lighted by
10 the external electrodes, the new problem arises that the internal electrodes sustain damage due to the discharge from the external electrodes.

As a countermeasure for a blackening phenomenon including this damage, in JP-A-5-144412, the blackening
15 phenomenon is reduced by incorporating mercury in an internally sealed gas with respect to an internal electrode type. It has also been proposed to fill deuterium gas in a gas discharge display panel that has a structure similar to that of a noble gas fluorescent
20 lamp.

However, when switching between the internal electrodes and the outer electrodes, the blackening phenomenon becomes worse than in the case of standard internal electrodes because the drive electric potential
25 of the external electrode lighting mode that discharges

through a dielectric material such as glass directly acts on the internal electrodes.

Also, as a light source having internal electrodes and external electrodes, there is a proposal for a structure in JP-A-2000-106146, but this is not a light source that switches between and lights two electrodes.

SUMMARY OF THE INVENTION

An object of the present invention is to solve the above problems. Namely, a light source of the invention includes: an airtight container having disposed therein a phosphor material that emits light by ultraviolet rays which are radiated due to discharge; a pair of internal electrodes disposed inside the airtight container; a pair of external electrodes disposed outside the airtight container; and a lamp controller that switches between an external electrode lighting mode resulting from the application of a voltage to the pair of external electrodes and an internal electrode lighting mode resulting from the application of a voltage to the pair of internal electrodes, wherein the lamp controller controls, in the external electrode lighting mode, an electric potential V_{IN} with respect to the pair of internal electrodes and an electric potential V_H of the electrode of the higher electric potential of the pair

of external electrodes to a condition where $V_{IN} > V_H$ or $V_{IN} \approx V_H$.

In the invention, the electric potential of the pair of external electrodes does not greatly touch the plus side with respect to the electric potential of the pair of internal electrodes. Thus, with respect to the discharge generated between the external electrodes and the internal electrodes, the internal electrodes always serve as anodes and a cathode sputtering phenomenon in the internal electrodes that had been a source of damage does not occur.

According to the invention, there is the following effect. Namely, in a light source used to switch between a visible reading mode and an infrared reading mode, the blackening phenomenon accompanying the switching between the external electrodes and the internal electrodes is controlled, and it becomes possible to extend the life of the light source.

20 BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of this invention will become more fully apparent from the following detailed description taken with the accompanying drawings in which:

Fig. 1 is a schematic diagram describing a first embodiment;

Fig. 2 is a diagram showing the waveform of a voltage applied to external electrodes;

5 Fig. 3 is a diagram showing spectral characteristics when a light source is driven in an external electrode mode;

Fig. 4 is a diagram showing spectral characteristics when the light source is driven in an
10 internal electrode mode;

Fig. 5 is a block diagram of an entire image reading device;

Fig. 6 is a diagram showing spectral characteristics of filters;

15 Fig. 7 is a diagram showing spectral sensitivity characteristics of CCD sensors; and

Fig. 8 is a schematic diagram describing a second embodiment.

20 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the invention will be described below on the basis of the drawings. Fig. 1 is a diagram describing the structure of a light source pertaining to the present embodiment. That is, a light source 1 is
25 disposed with a cylinder 2 including a transparent body,

and specifically glass or quartz, that can transmit not only visible light but also infrared light; a pair of caps 3 that respectively seal, so as to be airtight, both end portions of the cylinder 2; and a pair of
5 internal electrodes A and B that are respectively attached to the caps 3 and disposed inside the cylinder 2.

A noble gas, and preferably a gas including mainly xenon gas, is filled inside the cylinder 2. Phosphors
10 21 are disposed as a single layer on an inner surface of the cylinder 2. The phosphors 21 are coated so as to have an even thickness. However, in order to increase the amount of light emerging from the cylinder 2, there is a portion in a certain range of the inner surface of
15 the cylinder 2 where the phosphors are not coated. This portion extends in a band along the axial direction of the cylinder 2. A reflective film may be disposed between the cylinder 2 and the phosphors 21 excluding the certain range.

20 Also, a pair of external electrodes a and b is disposed on an outer surface of the cylinder 2. The external electrodes a and b are fixed to the cylinder by, for example, vapor-depositing a conductive metal material thereon or adhering a foil-like metal thereto.
25 The external electrodes a and b are disposed at mutually

separate positions and respectively extend along the axial direction of the cylinder 2.

The external electrodes a and b are not disposed in the aforementioned range. Thus, the light of the light
5 source 1 is emitted from a band-like opening portion. By applying a voltage to the internal electrodes A and B with this configuration, discharge is conducted between both. Also, by applying a voltage to the external
10 electrodes a and b, discharge is conducted between both. As will be described later, the discharge between the mutual internal electrodes and the discharge between the mutual external electrodes are different in terms of their aspects.

The internal electrodes A and B are fed with
15 electricity by an internal electrode-use feeder circuit (an internal electrode-use primary coil 41, an internal electrode-use secondary coil 42, an internal electrode-use transformer 43 and an internal electrode-use inverter circuit 44), and the external electrodes a and
20 b are fed with electricity by an external electrode-use feeder circuit (an external electrode-use primary coil 51, an external electrode-use secondary coil 52, an external electrode-use transformer 53 and an external electrode-use inverter circuit 54). The feeder circuits
25 convert direct currents from a direct-current power

source 7 to alternating currents at the inverter
circuits 44 and 54, feed the alternating currents to the
primary coils 41 and 51 of the transformers 43 and 53,
and boost the alternating currents at the secondary
5 coils 42 and 52.

The inverter circuits 44 and 54 are configured by a
switch, a transistor and a capacitor. A lighting order
signal is supplied from a lamp controller 6 to the
respective inverter circuits 44 and 54.

10 The internal switches of the inverter circuits 44
and 54 are switched ON by the lighting order signals,
and the direct currents from the direct-current power
source are converted to alternating currents. Thus,
when the internal electrode-use inverter circuit 44 is
15 switched ON, discharge is conducted between the internal
electrodes A and B, and the light source 1 emits light
in an internal electrode lighting mode.

Conversely, when the external electrode-use
inverter circuit 54 is switched ON, discharge is
20 conducted between the external electrodes a and b, and
the light source 1 emits light in an external electrode
lighting mode. When the lamp controller 6 does not
supply the lighting order signal to either of the
inverter circuits 44 or 54, electricity is not fed to

either of the electrode pairs and the light source 1 does not emit light.

Here, when light emission is conducted in the external electrode lighting mode, a discharge is generated between the internal electrodes, which are in an uncontrolled state. The waveforms of the voltages applied to the external electrodes are shown in Fig. 2. The electric potentials of the external electrodes a and b become mutually positive and negative high electric potentials, and an electric potential difference where the electric potential of the internal electrodes is lower arises between the external electrode of these whose electric potential is high and the internal electrodes.

Due to the discharge phenomenon generated at this time, a cathode sputtering phenomenon occurs where cations of the xenon in the internally filled gas are slammed against the internal electrodes, whose electric potential level is relatively low, due to the electric potential difference, whereby the electrode surface layers sustain damage, and substances knocked out from the electrodes adhere to the surrounding area and end up causing blackening.

As a countermeasure of the above, the present embodiment is disposed with a direct-current high

voltage supply 8 shown in Fig. 1. That is, the line between the light source 1 and the direct-current high voltage supply 8 is short-circuited in the external electrode lighting mode by a control signal from the lamp controller 6, whereby an electric potential level V_{IN} of the internal electrodes A and B is fixed at the electric potential level of the direct-current high voltage supply 8. By fixing the relationship between V_{IN} and a maximum V_H of the voltage applied to the external electrodes so that $V_{IN} > V_H$ or $V_{IN} \doteq V_H$, a large electric potential difference where the electric potential of the internal electrodes is lower does not arise between the internal electrodes and the external electrodes, and the cathode sputtering phenomenon also disappears.

Due to the discharge, the gas inside the cylinder is excited, light is emitted and the phosphors 21 are stimulated. Thus, the phosphors 21 generate light corresponding to the components of the phosphors 21. The phosphors 21 are excited to a resonance line of a wavelength of 147 nm or a resonance line of a wavelength of 147 nm and 172 nm of the light that the xenon atoms included in the gas emit, cause the phosphors that respectively emit blue (B), green (G) and red (R) light to emit light and generate visible light.

Separate from this, the xenon atoms also emit infrared light. The ratio of the emissions of infrared light and ultraviolet light changes according to the discharge state of the gas. The spectral characteristics when the internal electrode lighting mode and the external electrode lighting mode are switched in this manner are shown in Figs. 3 and 4. As stated in the "Prior Art" section, when the light source 1 is driven in the external electrode lighting mode, the ultraviolet light of the light emitted from the xenon atoms efficiently emitted and converted to visible light by the phosphors (see Fig. 3).

In the internal electrode lighting mode, the spectral characteristics shown in Fig. 4 can be obtained because the infrared light component of the components of light emitted from the xenon atoms is large, for the reasons stated in the "Prior Art" section.

An image reading device utilizing this characteristic change is described below. Fig. 5 is a block diagram of the entire image reading device. A reading document placed on a platen of the device is illuminated by the light source 1 mounted in a scanning unit U1, and the light reflected therefrom is guided to an imaging lens L by scanning mirrors of the scanning unit U1 and a scanning unit U2 and imaged in 3 line

color image sensors (CCD). Due to this mechanism, the document information is successively scanned in the subscanning direction, whereby the image sensor is made to scan and expose the document to conduct reading.

5 Here, due to the action of a device control section 100 that controls the entire device, a lamp control unit 101 conducts lighting control of the light source 1, a scanning control unit 102 conducts movement control of the scanning units U1 and U2, an image processing
10 section 103 conducts control of a processing circuit of a reading signal, and a filter switching control unit 104 conducts switching control of filters on an imaging light path.

 In the lighting control of the light source 1 by
15 the lamp control unit 101, switching of lighting/lighting extinguishment and visible light emission/infrared light emission is conducted. In the control of the scanning units U1 and U2 by the scanning control unit 102, control of the scanning reading
20 position, scanning reading rate and scanning direction is conducted. The switching control of the filters by the filter switching control unit 104 is one that switches between a visible light transmitting and infrared cutting filter F1 and a visible light cutting
25 and infrared light transmitting filter F2.

The two filters F1 and F2 placed in parallel in front of the lens are moved in a direction orthogonal to the lens optical axis (see the arrows in the drawing) and switched so that one of the two filter F1 and F2 is
5 inserted in the imaging light path.

Here, the 3 line color image sensors (CCD) used in the color image reading device are ones where color filters of the respective colors of R, G and B are formed on three reading pixels rows created on a single
10 chip. The spectral sensitivity characteristics thereof are shown in Fig. 7.

As for the characteristics of these color filter, although they have transmittance characteristics of a wavelength band corresponding to each reading color in a
15 visible light wavelength of 700 nm or lower, all of the colors have an unnecessary transmittance wavelength band in the near-infrared region of 700 nm or higher.

In ordinary reading, in order to cut the characteristic of the unnecessary transmittance region
20 that ends up becoming noise information, the visible light transmitting and infrared cutting filter F1 shown in Fig. 6 is incorporated and reading is conducted.

Conversely, when infrared reading is conducted, the sensitivity of the unnecessary transmittance wavelength
25 band of the color filter is used to advantage and the

visible light cutting and infrared transmitting filter F2 shown in Fig. 6 is used, whereby reading of the infrared region is conducted.

As for the spectral response when the visible light
5 cutting and infrared transmitting filter F2 is incorporated, although there are virtually no differences in the three channels of R, G and B, the output of the R channel, whose absorption from the red region of the color filter to the infrared is small, is
10 used as an infrared reading signal.

Due to the above-described mode switching of the light source 1 and the switching of the filters F1 and F2, it becomes possible to conduct reading of high precision where the noise component is removed in both
15 modes.

Next, a second embodiment will be described. Fig. 8 is a schematic diagram describing the second embodiment. The light emitting system of the light source 1 pertaining to the second embodiment is
20 characterized by means for controlling the application of voltage to the internal electrodes A and B in the external electrode lighting mode.

That is, although means where the internal electrode voltage in the external electrode lighting
25 mode was such that $V_{IN} > V_H$ or $V_{IN} \approx V_H$ with respect to

the electric potential V_H of the external electrodes in the previously described first embodiment was realized by disposing the direct-current high voltage supply 8 (see Fig. 1), this is realized in the second embodiment
5 by a control circuit 9 and a switching unit 10.

For example, the switching unit 10 is disposed between the external electrodes and the internal electrodes, and the electric potential of the internal electrodes A and B is controlled by the control circuit
10 10 so that it matches an electric potential that is the same as the electric potential of the electrode whose electric potential is the higher of the external electrodes a and b.

In other words, in the external electrode lighting
15 mode, although voltages are applied to the external electrodes a and b with the waveforms shown in Fig. 2, a voltage is applied to the internal electrodes A and B so that it matches an electric potential that is the same as the electric potential of the electrode of the higher
20 electric potential of this waveform.

Thus, the voltage V_{IN} of the internal electrodes A and B in the external electrode lighting mode can be fixed so that so that $V_{IN} > V_H$ or $V_{IN} \neq V_H$, a large electric potential difference where the electric
25 potential of the internal electrodes A and B is lower

does not arise between the internal electrodes A and B and the external electrodes a and b, the cathode sputtering phenomenon is eliminated and the blackening phenomenon can be controlled.

5 Also, other means for matching the electric potential of the internal electrodes A and B to a potential so that it matches an electric potential that is the same as the electric potential of the electrode whose electric potential is the higher of the external
10 electrodes a and b can be realized by disposing a rectifying unit of a high withstanding pressure.